or signal in order to determine a change in pressure, location, direction, speed and acceleration for each object on the plane of the touch screen. This information can be subsequently used to perform an action as for example moving a pointer or cursor or making a selection as indicated in block **290**.

FIG. **16** is a flow diagram of a digital signal processing method **300**, in accordance with one embodiment of the present invention. By way of example, the method may generally correspond to block **286** shown and described in FIG. **15**. The method **300** generally begins at block **302** where the raw data is received. The raw data is typically in a digitized form, and includes values for each node of the touch screen. The values may be between 0 and 256 where 0 equates to the highest capacitive coupling (no touch pressure) and 256 equates to the least capacitive coupling (full touch pressure). An example of raw data at one point in time is shown in FIG. **17**A. As shown in FIG. **17**A, the values for each point are provided in gray scale where points with the least capacitive coupling are shown in white and the points with the highest capacitive coupling are shown in black and the points found between the least and the highest capacitive coupling are shown in gray.

Following block **302**, the process flow proceeds to block **304** where the raw data is filtered. As should be appreciated, the raw data typically includes some noise. The filtering process is configured to reduce the noise. By way of example, a noise algorithm may be run that removes points that aren't connected to other points. Single or unconnected points generally indicate noise while multiple connected points generally indicate one or more touch regions, which are regions of the touch screen that are touched by objects. An example of a filtered data is shown in FIG. **17**B. As shown, the single scattered points have been removed thereby leaving several concentrated areas.

Following block **304**, the process flow proceeds to block **306** where gradient data is generated. The gradient data indicates the topology of each group of connected points. The topology is typically based on the capacitive values for each point. Points with the lowest values are steep while points with the highest values are shallow. As should be appreciated, steep points indicate touch points that occurred with greater pressure while shallow points indicate touch points that occurred with lower pressure. An example of gradient data is shown in FIG. **17**C.

Following block **306**, the process flow proceeds to block **308** where the boundaries for touch regions are calculated based on the gradient data. In general, a determination is made as to which points are grouped together to form each touch region. An example of the touch regions is shown in FIG. **17**D.

In one embodiment, the boundaries are determined using a watershed algorithm. Generally speaking, the algorithm performs image segmentation, which is the partitioning of an image into distinct regions as for example the touch regions of multiple objects in contact with the touchscreen. The concept of watershed initially comes from the area of geography and more particularly topography where a drop of water falling on a relief follows a descending path and eventually reaches a minimum, and where the watersheds are the divide lines of the domains of attracting drops of water. Herein, the watershed lines represent the location of pixels, which best separate different objects touching the touch screen. Watershed algorithms can be widely varied. In one particular implementation, the watershed algorithm includes forming paths from low points to a peak (based on the magnitude of each point), classifying the peak as an ID label for a particular touch region, associating each point (pixel) on the path with the peak. These steps are performed over the entire image map thus carving out the touch regions associated with each object in contact with the touchscreen.

Following block **308**, the process flow proceeds to block **310** where the coordinates for each of the touch regions are calculated. This may be accomplished by performing a centroid calculation with the raw data associated with each touch region. For example, once the touch regions are determined, the raw data associated therewith may be used to calculate the centroid of the touch region. The centroid may indicate the central coordinate of the touch region. By way of example, the X and Y centroids may be found using the following equations:

$$Xc=\Sigma Z^*x/\Sigma Z; \text{ and}$$

$$Yc=\Sigma Z^*y/\Sigma Z,$$

where

Xc represents the x centroid of the touch region

Yc represents the y centroid of the touch region

x represents the x coordinate of each pixel or point in the touch region

y represents the y coordinate of each pixel or point in the touch region

Z represents the magnitude (capacitance value) at each pixel or point

An example of a centroid calculation for the touch regions is shown in FIG. **17**E. As shown, each touch region represents a distinct x and y coordinate. These coordinates may be used to perform multipoint tracking as indicated in block **312**. For example, the coordinates for each of the touch regions may be compared with previous coordinates of the touch regions to determine positioning changes of the objects touching the touch screen or whether or not touching objects have been added or subtracted or whether a particular object is being tapped.

FIGS. **18** and **19** are side elevation views of an electronic device **350**, in accordance with multiple embodiments of the present invention. The electronic device **350** includes an LCD display **352** and a transparent touch screen **354** positioned over the LCD display **352**. The touch screen **354** includes a protective sheet **356**, one or more sensing layers **358**, and a bottom glass member **360**. In this embodiment, the bottom glass member **360** is the front glass of the LCD display **352**. Further, the sensing layers **358** may be configured for either self or mutual capacitance as described above. The sensing layers **358** generally include a plurality of interconnects at the edge of the touch screen for coupling the sensing layer **358** to a sensing circuit (not shown). By way of example, the sensing layer **358** may be electrically coupled to the sensing circuit through one or more flex circuits **362**, which are attached to the sides of the touch screen **354**.

As shown, the LCD display **352** and touch screen **354** are disposed within a housing **364**. The housing **364** serves to cover and support these components in their assembled position within the electronic device **350**. The housing **364** provides a space for placing the LCD display **352** and touch screen **354** as well as an opening **366** so that the display screen can be seen through the housing **364**. In one embodiment, as shown in FIG. **18**, the housing **364** includes a facade **370** for covering the sides the LCD display **352** and touch screen **354**. Although not shown in great detail, the facade **370** is positioned around the entire perimeter of the LCD display **352** and touch screen **354**. The facade **370** serves to hide the interconnects leaving only the active area of the LCD display **352** and touch screen **354** in view.